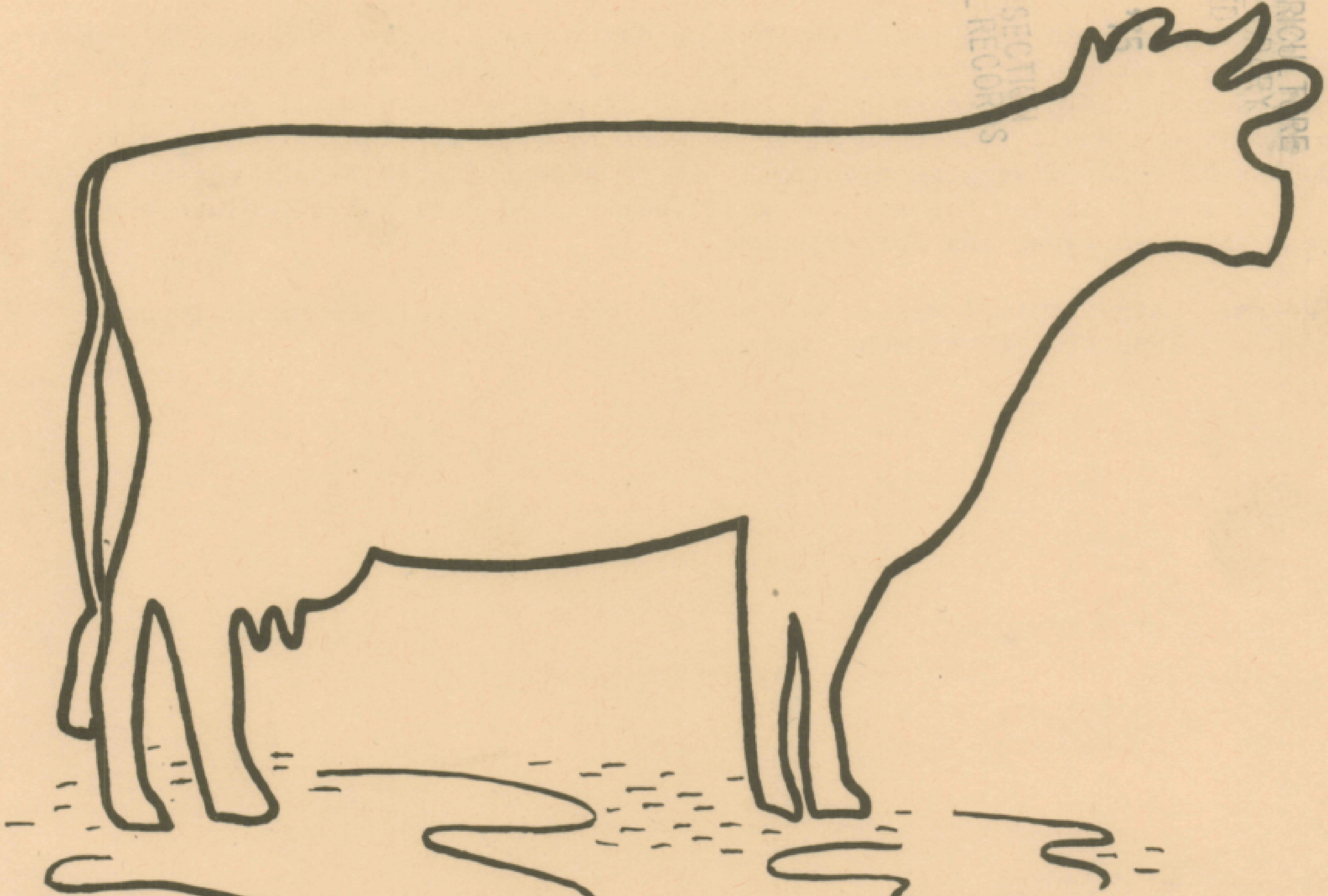
ECONOMIC IMPACT OF CONTROLLING SURFACE WATER RUNOFF FROM U.S. DAIRY FARMS



U.S. DEPARTMENT OF AGRICULTURE

ECONOMIC RESEARCH SERVICE

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ABSTRACT

U.S. dairy farmers will soon be faced with Environmental Protection Agency waste control regulations. This study estimated the investment and annual costs they will incur for lot runoff control and solid waste storage systems.

Findings indicate that total investment for facilities and equipment to control lot runoff for typical dairy farms, assuming all U.S. dairy producers have lot discharge problems, would be $780 million. An estimated 40 percent of the dairy producers actually have problems. This would represent an aggregate investment of $312 million.

EPA regulations will fall heaviest on dairy farms with fewer than 20 cows, where investment could be almost $200 per cow and the cost of producing 100 pounds of milk could increase by 45 cents. Exempting these small producers from compliance would reduce total investment to $528 million, assuming all producers have lot discharge problems. It is expected that runoff control regulations will hasten the exit of small dairy producers and stimulate the current shift to fewer and larger farms.

Key Words: Dairy, animal waste, pollution, runoff control, economic impact, industry, investment costs.

Washington, D. C. 20250 June 1974

PREFACE

The Federal Water Pollution Control Act Amendments of 1972 require the U.S. Environmental Protection Agency (EPA) to establish effluent limitation guidelines for point source discharges. Section 301(b) of the Act requires the application of the "best practicable control technology currently available" by July 1, 1977. By July 1, 1983, the Act requires the application of the "best available technology economically achievable."

Guidelines proposed by EPA for cattle feeding, dairy and swine production, and poultry and egg production appeared in the Federal Register of September 7, 1973. They were:

> "(a) The effluent limitation representing the degree of effluent reduction obtainable by the application of the best practicable control technology currently available is no discharge of process waste water pollutants to navigable waters, except for runoff which is not contained by facilities designed, constructed, and operated to contain all process waste water in addition to the runoff from the 10 year, 24 hour rainfall event as established by the U.S. Weather Bureau for the region in which the point source discharger is located.
>
> "(b) The effluent limitation representing the degree of effluent reduction obtainable by the application of the best available technology economically achievable is no discharge of process waste water pollutants to navigable waters, except for runoff which is not contained by facilities designed, constructed, and operated to contain all process waste water in addition to the 25 year, 24 hour rainfall event as established by the U.S. Weather Bureau for the region in which the point source discharger is located."

In the proposed guidelines of September 1973, a "feedlot" and "process waste water" were defined as follows:

> (a) The term "feedlot" shall mean a concentrated, confined animal or poultry growing operation for meat, milk or egg production, or stabling, in pens or houses wherein the animals or poultry are fed at the place of confinement and crop production is not sustained in the area of confinement.

(b) The term "process waste water" shall mean any water from any source which comes into contact with any manure, litter or bedding, or any other raw material or intermediate or final material or product used in or resulting from the production of animals or poultry or direct products (e.g. milk, eggs).

EPA subsequently announced that the effluent guidelines proposed on September 7 will apply only to operations with 1,000 animal units or more, e.g., 1,000 beef cattle, 2,500 swine, or 700 dairy cattle. It is possible that guidelines for smaller operations will be proposed for public comment at a later date.

The Economic Research Service initiated analyses of the cattle feeding, dairy, and swine industries before the passage of the Federal Water Pollution Control Act Amendments of 1972. The purpose of these analyses were to: appraise the extent of point source surface water runoff; estimate investments and additional operating costs needed to control runoff; and evaluate the economic impacts, including supply and price effects, of the application of effluent guidelines.

Because effluent guidelines had not been issued at the time the studies were started, they were assumed for these studies. Assumptions were based on preliminary information available to EPA, and on feedlot control practices in major producing States. Although the guidelines assumed do not coincide exactly with the guidelines announced in September 1973, they are sufficiently close to the announced guidelines to allow meaningful judgments of economic impacts. In making these estimates it was assumed that all feedlots, regardless of size, would have to comply with effluent guidelines.

This report appraises the economic impact of proposed regulations on the U.S. dairy industry. Data used were obtained from persons knowledgeable about the dairy industry and waste management control technology. Additionally, the National Milk Producers Federation made available the results of a survey on waste management. The survey covered producer members of cooperatives that belong to the National Milk Producers Federation. It was carried out by the field staff of that organization.

Appreciation is extended to all those who provided estimates, and especially to the National Milk Producers Federation, which made survey data available to the authors.

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DEFINITIONS OF TERMS

Wash water--Rinse water and floor washings from the cleaning and operation of milking parlors, milkhouses, and livestock holding areas.

Diversion terrace--An earthen embankment that channels uncontaminated water away from exposed lots and housing area, and diverts contaminated water into a holding pond, lagoon, or other retention structure.

Holding pond--An earthen pit with an embankment, for temporary storage of runoff and waste water.

Settling basin--A tank or pond with concrete bottom; speed of runoff and waste water flow allows a large part of the solids to settle out of suspension.

Stack system--A water-tight, solid-manure structure for storing a 6-month accumulation of waste, filled by stationary or swinging elevators.

Sump pit--Concrete structure built in the ground, for the collection and pumping of lot runoff and wash water.

10-Year, 24-hour storm event--Heaviest rainfall (in inches) that would fall during a 24-hour period with a frequency occurrence of once in 10 years.

Liquid storage tank--A water-tight, under-floor or outdoor underground concrete structure, designed to store a 6-month accumulation of waste.

SUMMARY

Public concern about water quality has prompted the U.S. Congress to start action to clean up the Nation's surface water supply. The Federal Water Pollution Control Act Amendments of 1972 (FWPCA of 1972) gives the Environmental Protection Agency (EPA) responsibility for this task. Runoff from exposed dairy lots is part of the pollution concern.

This report provides estimates of the added investment and annual costs dairy operators will incur in controlling runoff from normal rainfall, wash water, and major storm events. Estimates were based on typical size farms in three important dairy regions, and applied to 48 States. Investment and annual cost for individual farm operators, and the aggregate capital investment for the industry, will be influenced by the policy decisions regarding runoff control guidelines. Factors specifically considered in this report are: (1) increasing the capacity of facilities to store runoff from dairy farms, (2) varying the length of the storage period, and (3) exempting various size categories of producers from complying with guidelines.

This report considers the most feasible systems for retaining dairy runoff on the farm property. Systems vary somewhat by regions, but basically they include clear-water diversion terraces above the drainage area, settling basins, holding ponds, and an irrigation system to move dirty water onto the land. Both the manure stacking and liquid manure storage systems were studied as alternatives to spreading the waste on frozen ground.

Results of the study indicate that the greatest financial impact of runoff control would fall on dairy farmers with fewer than 20 cows. Investment would be almost $200 per cow, which would increase annual cost per cow $50 to $65, and add 45 cents to the cost of producing 100 pounds of milk. Dairy farmers in the colder climates would have to invest an additional $240 per cow if they were required to store manure in an impervious structure for 6 months, rather than spread it on frozen land.

The financial impact of runoff control on a farm with 20 or more cows is significant but much less so than on a smaller farm. Investment per cow in the Northern region would be about $187 for a 15-cow herd, $69 for a 30-cow herd, and $25 for a 150-cow herd. Increases in the cost of producing 100 pounds of milk would be about 42 cents, 16 cents, and 6 cents for the three size herds, respectively. Similar results were found in the other regions considered, although there were some important differences.

Doubling the storage capacity for runoff would increase investment on individual dairy farms and for the entire dairy industry by 20 percent.

If all milk producers were required to control runoff from a 10-year, 24-hour storm, total industry investment would be about $780 million. Exempting dairy farmers with fewer than 20 cows would reduce total investment to $528 million, or a drop of 32 percent. Exempting dairy farmers with fewer than 100 cows would reduce total investment to $80 million, or a drop of 90 percent.

In the short run, the impact of the cost of pollution control would be borne by the dairy farmer. Because milk is produced under a wide range of cost and farm size situations, the industry's overall efficiency may even improve after pollution regulations are imposed. This would result from small farms being forced out, or forced to expand and adopt more efficient housing and milking technologies.

IMPLICATIONS OF EPA REGULATIONS

This analysis presents a range of situations that would probably reflect the actual alternatives and costs if regulations for runoff control from dairy farms are developed and enforced. It provides estimates of the upper limit of aggregate investment for the dairy industry, while recognizing that producers will choose the alternative that will bring them into compliance with regulations at the least possible cost.

Several responses can be expected if dairy farmers are faced with some of the cost increases calculated in this study. Responses will depend, in part, on the age of the operator, his financial status and credit availability, and whether a son or other relative plans to assume ownership of the operation. Keeping these factors in mind, it is expected that:

(1) Some producers will not attempt to comply; they will either quit the dairy business or continue until they have no choice except to cease operation. Producers with good crop alternatives will drop dairying and specialize in crops.

(2) Some producers will comply with regulations, and either absorb the cost or expand herd size to leave their net incomes unchanged.

(3) Some producers will shift to new housing, milking, and animal waste handling technologies in order to comply with regulations. Herd expansion usually accompanies this type of adjustment. For example, a confinement housing system with liquid manure storage would eliminate runoff and the need to spread manure on frozen land. These features would encourage the adoption of confinement housing. The cost of such a change, then, could not be attributed entirely to animal waste regulations. To the extent this type of adjustment actually occurs, fewer holding ponds would be needed, and total industry investment would be less than indicated in this study.

The added cost of runoff control cannot be immediately passed on to consumers. In the short run it must be absorbed by producers. Only after the industry adjusts over a longer time period will the costs be passed on to consumers--due mainly to an expanded market, a lower supply of milk than otherwise would be the case, and correspondingly higher milk prices. Higher costs will directly reduce net farm income in the short run, and stimulate adjustments in the dairy industry in the longer run.

Runoff control regulations that reduce net cash income will have a greater impact on small than on large farms. Small operators are likely to have greater difficulty obtaining money for needed investment. This situation will hasten their exit from the industry and, in turn, stimulate the shift to fewer and larger dairy farms. This shift will be in addition to the change already projected to 1976, which was used as a base for this study. After industry adjustment, consumer prices will probably increase up to 10 cents per 100 pounds of milk.

Consumer prices may not be appreciably higher in the long run. Increases will depend on the extent individual producers expand production in order to maintain their net incomes, and exit of the less efficient farmers from the industry, leaving more efficient ones in operation. At least, the price increase will be less than increased production costs might suggest.

Producers in the Northern region will be placed at a relative disadvantage to those in other regions in the event of regulations on winter spreading of manure. This would double the cost of runoff control and intensify industry adjustments for the region.

Runoff control regulations can vary regarding the volume of storage capacity required to retain surface runoff from the lot and drainage area. The analysis indicates that doubling the storage capacity adds only 20 percent to total investment. This suggests that the additional cost of providing larger holding facilities is relatively small, although it is quite large in absolute amount. Increasing the storage period for normal rainfall and wash water from 1 to 3 weeks would have very little effect on total capital investment by the industry. Thus, making the guidelines and regulations more stringent would have less impact than imposing the guidelines in the first place.

Designing a storage pond to hold "normal rainfall" would actually mean overdesigning the capacity because not all of the rainfall finds its way into the pond. The intensity of rainfall, lot surface, and lot slope affect the quantity of runoff. Research in Nebraska by the Agricultural Research Service indicates that because of water-absorbing capacity of the soil-manure mixture on the lot surface, "runoff may not be expected after smaller than half-inch rains unless rainfall has occurred within the previous 3 days." No runoff could be expected after a 1-inch rain following a summer dry period (10).

Results of this analysis indicate that exempting dairy farm operators with fewer than 20 cows from pollution regulations would reduce aggregate capital investment in the industry by 32 percent. Exempting dairy farm operators with fewer than 100 cows would reduce aggregate capital investment by 90 percent. Investment, annual operating costs, and milk production costs would have the heaviest relative impact on small producers.

ECONOMIC IMPACT OF CONTROLLING SURFACE WATER RUNOFF FROM U.S. DAIRY FARMS

by

Boyd M. Buxton and Stephen J. Ziegler*

INTRODUCTION

Growing public concern over environmental quality prompted Congress to enact the "Federal Water Pollution Control Act Amendments of 1972" on October 18 of that year. In this Act, the U.S. Environmental Protection Agency (EPA) was charged with developing a comprehensive national program to eliminate water pollution. Federal guidelines are now being developed to insure that all States make progress in reducing or eliminating the pollutants entering the Nation's water supply.

Pollution from agriculture was included as part of this program to clean up the Nation's water. Among other groups, livestock producers and dairy farmers will be directly affected by these guidelines because of exposed lots that are subject to runoff from storm events and from other point-source discharges such as wash water used on many dairy farms. This report specifically considers point source discharges as they relate to the dairy industry. It also evaluates the economic impact of reducing nonpoint discharges of dairy wastes resulting from manure disposal on frozen ground, and the subsequent spring runoff.

Like society in general, dairy farmers are concerned with water quality, and most of them are willing to make additional investments or alter their management practices in order to improve the water quality. Regulatory authorities, in turn, should consider the economic impact of proposed standards. Among the most important questions are: How many dairy farms will be affected by the regulations? How will producers' costs be changed? Will the additional cost force a large number of dairy farms to discontinue milk production?

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*Agricultural Economist, Economic Research Service, U. S. Department of Agriculture; and Research Specialist, Department of Agricultural and Applied Economics, University of Minnesota, respectively.

PROCEDURES FOR THE STUDY

Three important dairy regions were selected for this study--Northern, Southeast, and Southwest (fig. 1). They were selected on the basis of variations in rainfall and in problems of dairy farmers in complying with pollution control regulations. By 1976, there will be an estimated 305,800 dairy farms in the 48 contiguous States. These three regions represent about 80 percent of total milk production and 75 percent of the dairy herds.

The additional equipment and facilities needed to store and dispose of runoff and wash water were determined for representative sizes of farms in each region. Equipment and facilities needed to store manure for more timely disposal were determined for representative size dairy farms in the Northern region. The systems providing the most practical means available for milk producers to comply with anticipated pollution control regulations were synthesized for these "typical" farms. Costs of additional equipment and facilities were estimated from equipment dealer prices, secondary sources, and the recommendations of State, college, and U.S. Soil Conservation Service engineers.

Estimates of total investment and production costs for the dairy industry in the 48 States were based on costs for each herd size in the three study regions.

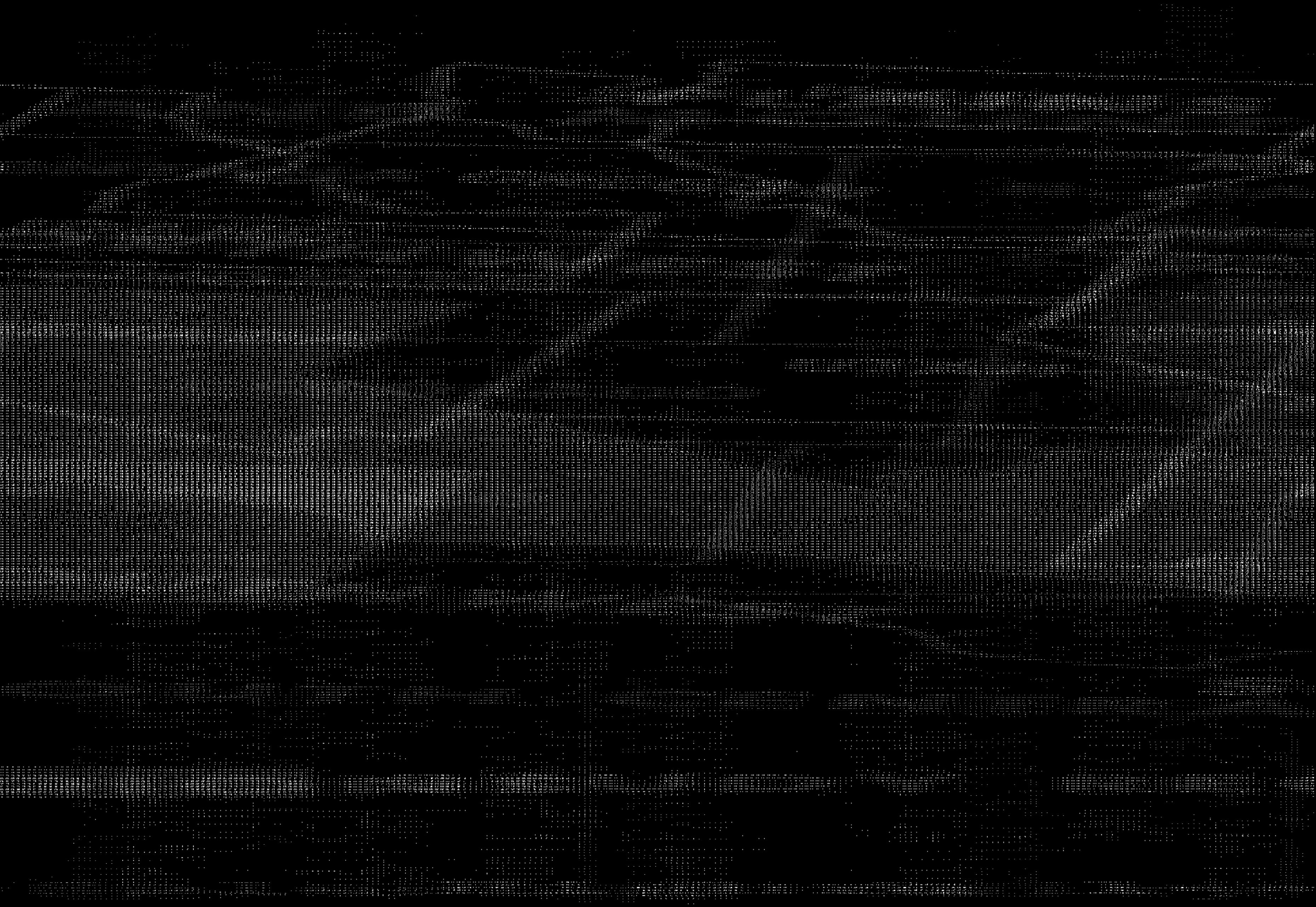
RUNOFF CONTROL ON U.S. DAIRY FARMS

Dairy farmers in every region are concerned with the problem of runoff control. However, many producers are taking a "wait and see" attitude regarding anticipated Federal regulations because of uncertainty about what can be done, and whether any action they take will meet future regulations. Because of this attitude, relatively few farmers have installed runoff control facilities. Many facilities already installed do not adequately control runoff from major storm events, since they were designed for wash water only.

Because of location, drainage of exposed lots, and the general farm layout, many dairy operators do not pollute surface water under normal rainfall conditions. However, others are located on or near a stream or other surface water, where precautions must be taken to prevent runoff from entering surface water. In the absence of collection facilities, runoff and wash water from these farms moves into dry ditches and natural drainage courses and, in the event of excess runoff volume, could enter surface water.

Northern Region

The Northern region covers a large area. Stanchion barns with outside lots and some type of solid-manure handling system are common--especially on



smaller farms. Typically, these farms have no special runoff collection facilities, and manure is usually spread on the fields daily during the winter months. Most producers have exposed lots, regardless of herd size. Therefore, they must control runoff, or build a totally covered system to eliminate it.

A few dairy operators have liquid manure storage systems. The largest concentration of these systems is in Michigan, where 19 in a sample of 340 above-average size producers reported having them. (9)

In a recent survey of 919 Northern region operators, 38 percent said that runoff from their exposed lots entered a continuously flowing stream, either directly or through a natural waterway or dry ditch, at least once each 10 years. Only 16 percent of the operators surveyed said that diversion terraces above the lot were needed to reduce the flow of water leaving the exposed lot surface. 1/

Runoff Control Systems

The settling basin-holding pond system, with a clean-water diversion terrace above the lot, provides a temporary means of storing runoff prior to its ultimate disposal by a sprinkler irrigation system on a field or pasture (fig. 2). This represents the best practical system for producers in the Northern region to control storm and snow melt runoff from exposed lots. Usually, the lot is located so there is sufficient space for construction of the holding pond; gravity flow carries the water from the lot through the settling basin into the pond.

Precipitation falling on barn roofs is assumed to be channeled away from the lot area by gutters, which dump the water outside the diversion terrace.

Animal Waste Disposal

Animal wastes spread on frozen ground remain intact during the winter months because there is minimal bacterial action. Spring rains and snow melt can wash organic wastes into surface waterways and lakes.

Dairy farmers in areas where there is no winter freeze of topsoils can usually incorporate manure into the soil, thus avoiding the problem of field runoff following winter waste disposal. To eliminate this problem in the Northern region, those dairy farmers not already doing so should store animal waste when the disposal area is frozen, and dispose of it after a thaw.

Two alternative systems are considered for animal waste storage in the Northern region: liquid storage tanks and solid stacking.

The liquid storage tank, located underground and close to the barn, is designed to store manure from the barn plus wash water from the milkhouse. A liquid manure spreader is used to spread the manure on the land when the

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1/ Tabulated from a survey of producer members of cooperatives that belong to the National Milk Producers Federation.

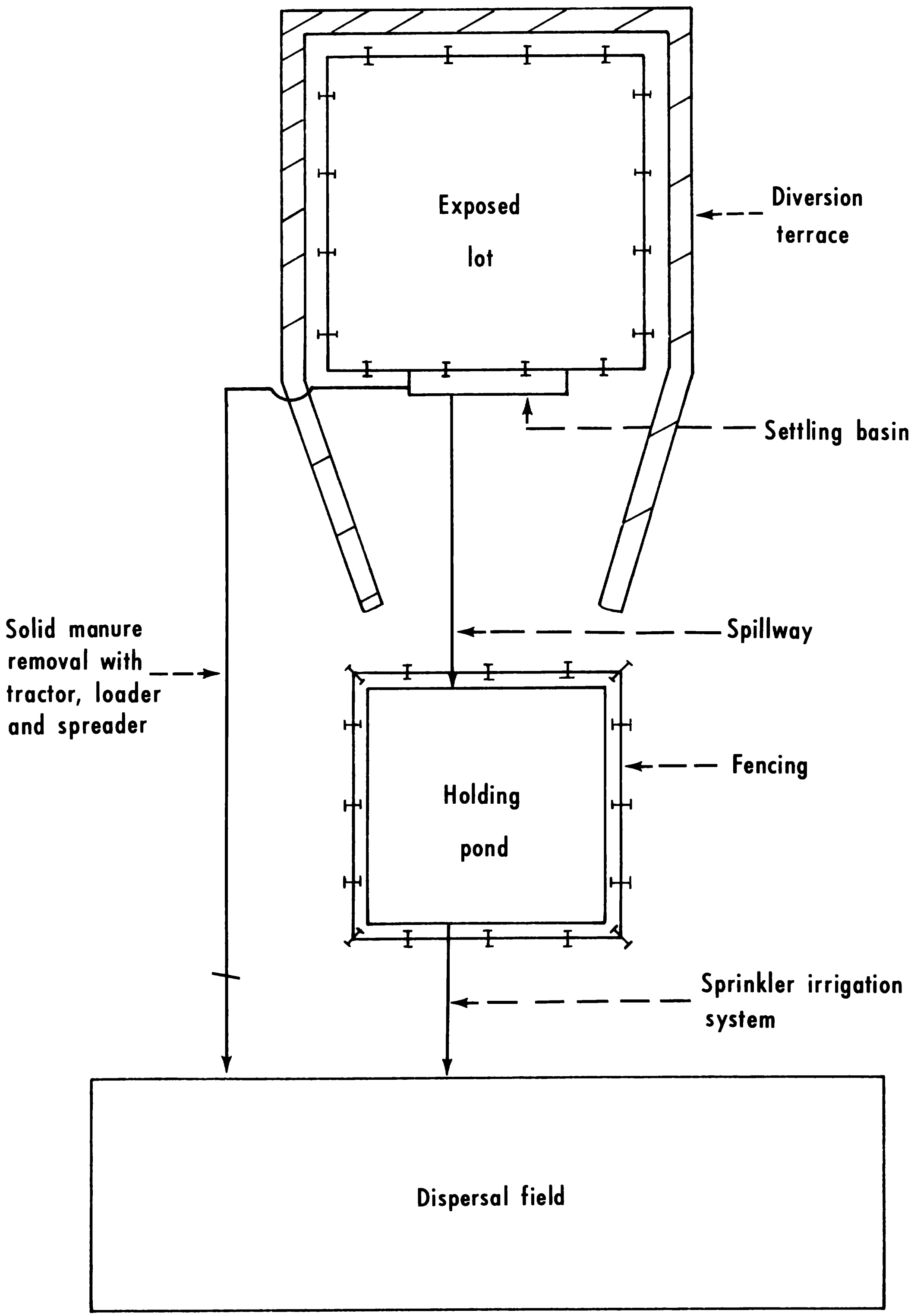

Figure 2--Settling basin-holding pond, Northern region dairy farms

soil is not frozen. Manure can be incorporated into the soil by injection, or by plowing immediately after disposal. This practice minimizes odor and reduces or eliminates surface runoff.

Stacking manure in a water-tight structure during winter months also eliminates winter spreading and possible runoff into surface water. As with the liquid storage tank, dry storage structures are designed to hold animal waste for 6 months. The wastes are carried by tractor loader to a solid manure spreader, and spread on the field when the soil is not frozen. Again, manure can then be incorporated into the soil.

Southeast Region

Southeast dairy farms are typically located so that runoff and wash water can drain into surface water. For example, in Florida, the large concentration of dairies near Lake Okeechobee, an important water supply, is of major concern to environmentalists and others, and underlies some of the pressure to control dairy waste. (14) Lagoon detention-pond systems are considered the most practical means of controlling runoff and wash water in this region. Nordstedt indicated, in a February 1973 report, that about 100 of these systems had been installed in Florida. (13) The typical lagoon system in this region consists of four major components: settling basin, anaerobic lagoon, overflow basin for storage, and flood sprinkler irrigation system (fig. 3).

Sprinkler cow-wash systems have increased the volume of wash water by 50 to 150 gallons per cow per day on the larger dairy farms. Uncontrolled, this volume of wash water is sufficient to carry waste material into surface water (13, p. 8). In addition, annual rainfall ranges from 50 to 65 inches and, on occasion, 10 inches or more may fall in a 24-hour period in most areas of Florida. Here, as in all other regions of the country, adequate runoff control facilities are essential.

In a recent survey, 159 of 351 producers (45 percent) surveyed in the Southeast region indicated that runoff from their exposed lots entered a continuously flowing stream at least once every 10 years. Twelve percent said they needed to divert water from above the lot.

Southwest Region

The Southwest region is the most heterogeneous of the three regions studied. There are essentially three subareas in California alone: the Northern coastal area, the San Joaquin Valley, and the Chino basin near Los Angeles. In all three areas, runoff is a problem.

Many dairy farms in northern California are located along the coast among rolling hills, and along wet and dry creek beds. Many of these sites were selected because their proximity to a stream or creek bed facilitated waste disposal. Producers have limited space to construct runoff control facilities because lots are close to streams. In order to keep runoff out of surface water, these producers would have to construct sump pits, and pump the waste water and runoff up into a suitable holding pond for storage and later irrigation on the land. (fig. 4)

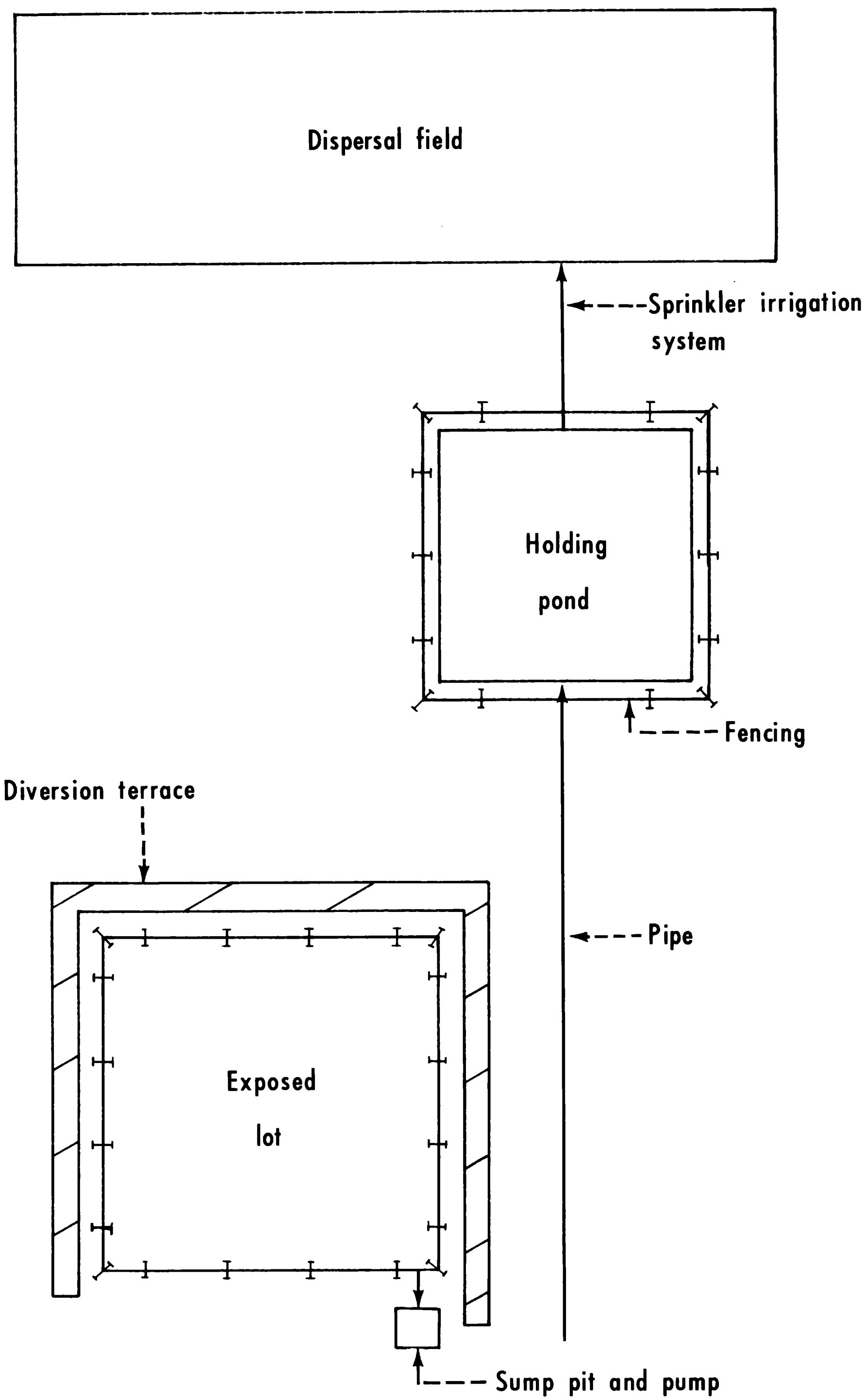

Figure 3--Anaerobic lagoon, Southeast region dairy farms

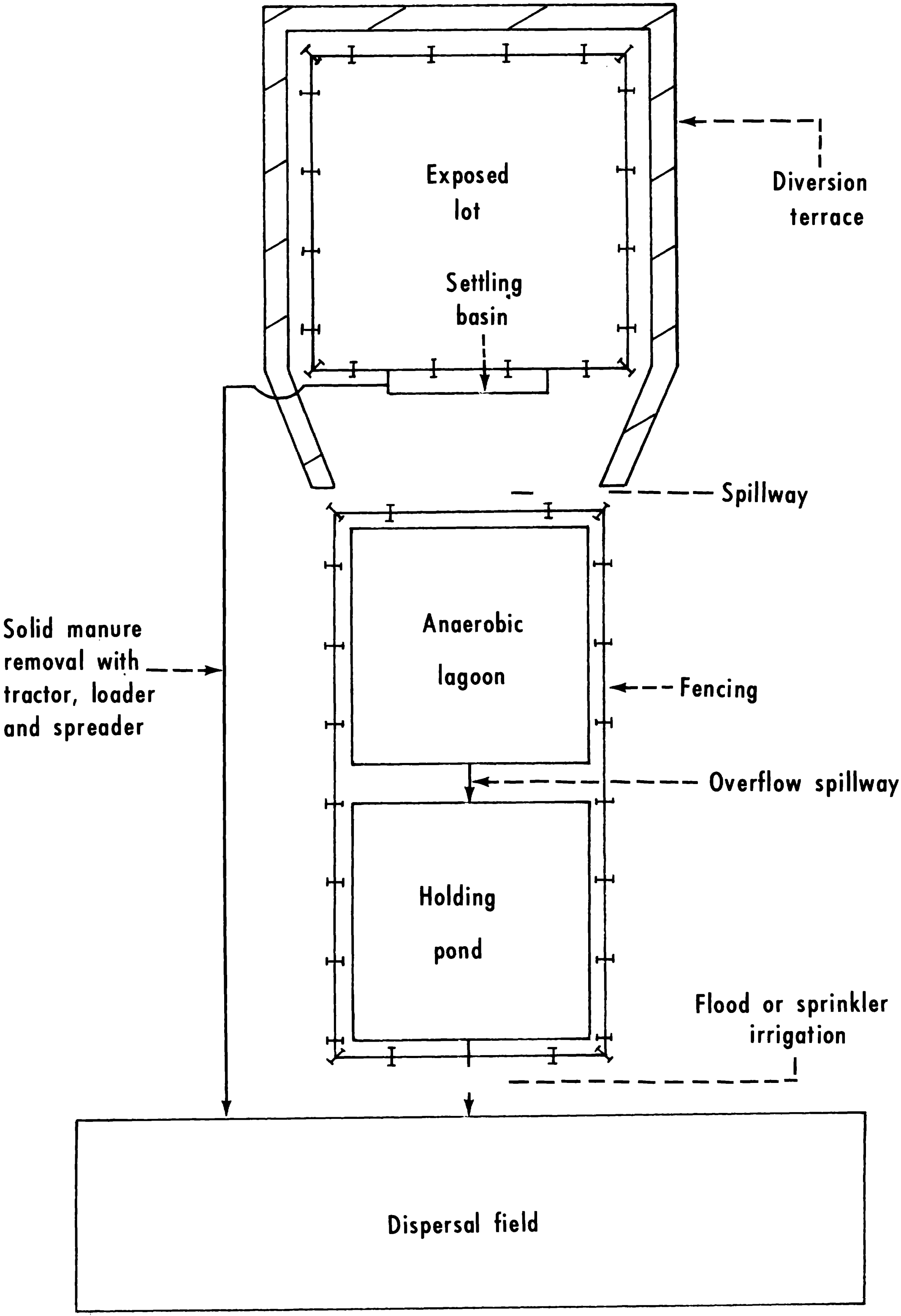

Figure 4--Sump pit-holding pond, Southwest region dairy farms

Sprinkler cow-wash systems, similar to those in the Southeast, contribute to the runoff problem. Some dairy farmers have tried to control this runoff. However, few of them have controlled runoff from exposed lots, and they do not have storage capacity for a major storm event such as the 10-year, 24-hour rain.

The San Joaquin Valley is flat, and has less rainfall than the northern coastal and Chino valley areas. Nearly all dairies have open exposed lots, and generate about 50 gallons of wash water per cow per day. Typically, the waste water from storage ponds is mixed with irrigation water, and then flood irrigated onto the farmland.

Partly out of concern for pollution control regulations, some dairy farmers have adopted a flush system. This system recycles water from a holding pond or uses daily wash water to flush manure from the alleys. About 75 percent of all manure goes into this system, leaving a relatively small amount to be handled as a solid. However, some of these systems (that include holding ponds) do not have the capacity to handle major storm events.

The Chino basin, surrounded by the urban towns of Riverside, Ontario, and Corona, is unique. Most of the 120,000 or so milk cows are concentrated in a 30-square-mile area. The average dairy farmer has about 650 cows and 45 acres of land; about two-thirds of his acreage is available for disposal of runoff and wash water. The dairy cattle population in this area now exceeds the capacity of the cropland available for recycling the animal wastes.

Chino basin dairy farmers already face stringent pollution control regulations imposed by the Santa Ana Regional Water Quality Board. However, retention facilities are designed to control only wash water. Control of both wash water and lot runoff will be a problem for many of these farmers, but solid manure disposal may prove to be their most serious problem.

Based on a sample of dairy farms in this area, an estimated 75 percent of the operators would be able to expand facilities and control wash water and lot runoff by means of a retention pond. (16) These estimates assumed 50 gallons of wash water per cow per day, and the runoff of a 4-inch storm from the corral and farmstead area. Water levels in ponds would be controlled by sprinkler irrigation.

Control of lot runoff, as well as storage and treatment of solid wastes, could also be handled by the lagoon treatment system. Lot runoff, solid wastes flushed from the barn, and wash water are channeled to the lagoon through the sump. Lagoon overflow moves by gravity into an overflow holding pond, then into a flood or sprinkler irrigation system. This system is generally applicable to all three areas in California, as well as in Arizona. Pumping into the holding pond would be necessary in many cases in northern California because of lack of space for a holding pond between surface water and exposed lots. Land in the San Joaquin and Chino valleys is flat. For this reason, the holding pond would have to be higher than the lot surface on most farms, which would necessitate pumping.

Storage requirements in the runoff control system depend on how frequently the holding pond is emptied, intensity of storm events, volume of wash water entering the holding pond, and size of the drainage area. The basic analysis in this study assumed that the holding pond had the capacity to store (1) all runoff from 3 weeks of normal rainfall during the highest rainfall period of the year, (2) 3 weeks of wash water, and (3) runoff from a 10-year, 24-hour storm event. This system would hold all runoff, including that from a 10-year, 24-hour storm event on any given day except during the 3 days following a major storm, when the pond is being emptied. This size holding pond could store an equivalent of 8, 16.7, and 11.1 inches of runoff from the drainage area in the Northern, Southeast, and Southwest regions, respectively (table 1). A later section will discuss the investment and annual cost for ponds (1) designed to hold only normal rainfall and wash water, and (2) designed to hold normal rainfall and wash water, plus runoff from 50 percent of annual precipitation.

In this study the surface area draining into the holding pond was considered to be a constant 450 square feet per cow for all regions. This includes the lot itself, the surface of the holding pond, and any other land between, but within, the polluted water diversion area (table 1). Most of the drainage area would be the lot itself, which was assumed to contain 300 square feet per cow in the Northern and Southeast regions and 375 square feet per cow in the Southwest region. 2/ Even though the lot was assumed to be larger in the Southwest, total drainage area would still be about 450 square feet per cow. Most producers in the Southwest would pump runoff from the lot into a holding pond, thereby eliminating most of the area outside the lot and the holding pond itself.

The cost of controlling runoff depends to a large extent on herd size. Therefore, different sizes of herds in each region were selected to evaluate investment and annual costs. The herd size classes were selected to represent typical dairy production units in each region. In this report, investment and annual costs were those required for existing dairy farms to control runoff. Operators who already have the facilities and equipment would not need to make any additional investment.

10-Year, 24-Hour Storm Event

In the Northern region, investment to control runoff from a 10-year, 24-hour storm plus wash water and normal rainfall will cost individual producers with 15 cows an estimated $2,799, or $187 per cow (table 2). Assuming the investment is depreciated over 5 years, annual cost would be about $757, or $50 per cow. This would be a substantial financial burden for the small

2/ (5) The recommended size of a dirt lot ranges from 300 to 600 or more square feet per cow and a paved lot from 35 to 100 square feet per cow. This study assumes a partly paved lot; therefore, 300 to 375 square feet per milk cow was assumed adequate.

producer, who normally has a relatively low net farm income. However, if costs were distributed over the useful life of the equipment and facilities, annual cost per cow would decline from $50 to $30 for this size of farm.

Table 1--Drainage area and capacity of holding ponds under various assumptions, Northern, Southeast, and Southwest regions

Item	Northern	Southeast	Southwest
		Square feet	
Surface area of exposed lot, per cow	300	300	375
Area draining into holding pond, per cow 1/	450	450	450
		Inches	
Average rainfall during wettest 3 weeks of year	3	6	2.4
Wash water, converted to inches of water on drainage area 2/	3/	3.7	3.7
Precipitation:			
10-year, 24-hour storm event	5	7	5
50 percent of annual precipitation	17	29	15
Total storage capacity of holding pond required to hold wash water plus--			
normal rainfall during highest rainfall period	3	9.7	6.1
normal rainfall plus 10-year, 24-hour storm event	8	16.7	11.1
50 percent of annual precipitation	20	38.7	21.1

1/ Includes lot, plus area outside lot, and pond surface.
2/ Assumes 50 gallons of wash water per cow per day in the Southeast and Southwest regions.
3/ Generally, much less water is used in the Northern region than in other regions.

Table 2--Investment and annual costs to collect, store, and dispose of runoff from a 10-year, 24-hour storm event, Northern region dairy farms 1/

Additional facilities and costs	Herd size			
	15	30	80	150
	Dollars			
Detention pond	84	167	446	836
Diversion terrace	146	208	346	459
Irrigation equipment	1,475	1,475	1,475	1,751
Tractor-mounted loader 2/	974	0	0	0
Fencing-detention pond	38	45	48	53
Settling basin	82	162	432	626
Total investment	2,799	2,057	2,747	3,725
Investment per cow	187	69	34	25
Annual cost, with 5-year depreciation:				
Depreciation	511	382	520	710
Interest	112	82	110	149
Repairs and maintenance	89	64	64	79
Insurance	6	3	3	3
Electricity	6	11	32	59
Labor	32	35	51	65
Tractor use	1	1	2	2
Total	757	578	782	1,067
Cost per cow	50	19	10	7
Cost per cwt. milk 3/	.42	.16	.08	.06
Change in annual cost, with useful life depreciation:				
Total	443	350	462	621
Cost per cow	30	12	6	4
Cost per cwt. milk 3/	.25	.10	.05	.03

1/ Assumes 3-week storage capacity for normal rainfall during highest rainfall period, plus capacity to store runoff from a 10-year, 24-hour storm event. This is equivalent to 8 inches of runoff from the total drainage area of 450 square feet per cow.

2/ It was assumed that most operators of farms with 15 cows would not have a tractor-mounted loader, whereas operators of larger farms would.

3/ Assuming 12,000 pounds of milk per cow per year.

Investment per cow to control runoff for 30- to 150-cow dairy farms would range from $69 to $25; additional annual cost per cow would range from $19 to $7 if investment is recovered in 5 years, and from $12 to $4 if investment is recovered over the estimated useful life of the equipment and facilities.

Assuming that operators of all size herds obtain 12,000 pounds of milk per cow per year, and investment depreciation over 5 years, increased production costs would range from 42 cents per 100 pounds of milk for a 15-cow farm to 6 cents for a 150-cow farm. These costs represent a 4 percent increase for the 15-cow farm and a 1 percent increase for a 150-cow farm (table 3). Again, the financial impact would be greatest on small operators.

In the Southeast region, investment to control 50 gallons of wash water per cow per day and normal rainfall for 3 weeks, plus a 10-year, 24-hour storm event, would range from $2,895 for the 15-cow farm to $13,257 for the 500-cow farm (table 4). Investment per cow would range from $193 on the 15-cow farm to $27 on the 500-cow farm. Investment would be a particular burden on small operators.

Assuming investment is depreciated over a 5-year period, increased annual costs per cow would range from $52 on the 15-cow to $9 on the 500-cow farm. Increased cost of producing 100 pounds of milk would range from 43 cents (or 4 percent increase) for small producers to 7 cents (or 1 percent increase) for large producers.

In the Southwest region, investment to control runoff from 50 gallons of wash water per cow per day and normal rainfall for a 3-week period, plus a 10-year, 24-hour storm event, would range from $3,548 for a 15-cow farm to $9,911 for a 500-cow farm (table 5). Investment per cow would range from $237 for the 15-cow farm to $20 for the 500-cow farm. The increase in annual cost per cow, excluding the 15-cow herds, ranges from $15 to $6. Increased production costs per 100 pounds of milk would range from 13 cents (a 4 percent increase) to 5 cents (a 1 percent increase).

50 Percent of Annual Precipitation

Surface runoff control from snow melt or storms excluding the 10-year, 24-hour equivalent storm event increases investment and production costs (table 6). Severe snow melt and storms could result in an additional 12 inches of runoff in the Northern region, 22 inches in the Southeast, and 10 inches in the Southwest from the 450-square-feet per cow drainage area. Cost for this additional runoff holding capacity would be about $10 per cow in the Northern and Southwest regions and $18 per cow in the Southeast region.

Length of Runoff Storage Period

If it were feasible to irrigate continuously, the holding pond could be reduced to a sump pit, and irrigation could be started as soon as runoff began. The investments and annual costs discussed above were based on irrigating no more than once each 3 weeks during the highest rainfall period, and less often during lower rainfall periods. That is, the holding pond was designed to hold

Table 3--Increased production costs for selected pollution control systems, by dairy herd size, Northern, Southeast, and Southwest regions

Item	Herd sizes (cows)													
	Northern				Southeast				Southwest					
	15	30	80	150	15	80	250	500	15	80	150	250	500
	Dollars													
Total production costs per 100 pounds of milk 1/	9.98	7.38	5.72	2/5.52	12.20	8.17	2/7.68	2/6.84	12.78	6.41	2/6.00	2/5.52	2/5.04
Added production costs per 100 pounds of milk for: 3/													
Holding pond system 4/	.42	.16	.08	.06	.43	.11	.08	.07	.54	.13	.09	.07	.05
(Percent increase)	(4.2)	(2.2)	(1.4)	(1.1)	(3.5)	(1.3)	(1.0)	(1.0)	(4.2)	(2.0)	(1.5)	(1.3)	(1.0)
Stacking system	.67	.29	.16	.13									
(Percent increase)	(6.7)	(3.9)	(2.8)	(2.4)									
Liquid storage system	--	.84	.52	.40									
(Percent increase)	--	(11.4)	(9.1)	(7.2)									

1/ (4). Adjusted by 1973 "prices paid" index.
2/ Estimated.
3/ 5-year depreciation schedule.
4/ Capacity to store 3 weeks of normal rainfall plus a 10-year, 24-hour storm event.
-- = not applicable.

Table 4--Investment and annual costs to collect, store, and dispose of runoff from a 10-year, 24-hour storm event, Southeast region dairy farms 1/

Additional facilities and costs	Herd size: 15	80	250	500
	Dollars			
Detention pond	177	945	2,954	5,908
Diversion terrace	146	346	593	836
Irrigation equipment	1,475	1,751	2,563	3,689
Tractor-mounted loader 2/	974	0	0	0
Fencing-detention pond	41	54	98	116
Settling basin	82	432	1,356	2,708
Total investment	2,895	3,528	7,564	13,257
Investment per cow	193	44	30	27
Change in annual cost, with 5-year depreciation:				
Depreciation	529	670	1,503	2,578
Interest	116	141	303	530
Repairs and maintenance	91	78	113	163
Insurance	6	3	3	4
Electricity	22	113	351	619
Net change-labor	15	75	226	452
Net change-tractor use	1	3	6	12
Total	780	1,083	2,505	4,358
Cost per cow	52	14	10	9
Cost per cwt. milk 3/	.43	.11	.08	.07
Change in annual cost, with useful-life depreciation:				
Total	454	663	1,540	2,678
Cost per cow	30	8	6	5
Cost per cwt. milk 3/	.25	.07	.05	.04

1/ Assumes 50 gallons of wash water per cow per day, 3-week storage capacity for wash water and normal rainfall during the highest rainfall period, plus capacity to store runoff from a 10-year, 24-hour storm event. This is equivalent to 16.7 inches of runoff from the total drainage area of 450 square feet per cow.

2/ It was assumed that most operators of farms with 15 cows would not have a tractor-mounted loader, whereas operators of large farms would.

3/ Assumes 12,000 pounds of milk per cow per year.

Table 5--Investment and annual costs to collect, store, and dispose of runoff from a 10-year, 24-hour storm event, Southwest region dairy farms 1/

Additional facilities and costs	Herd sizes (cows) 15	80	150	250	500
	Dollars				
Detention pond	119	634	1,189	1,982	3,963
Diversion terrace	88	202	275	356	503
Irrigation equipment	1,475	1,475	1,751	2,287	2,862
Fencing-detention pond	39	50	60	88	102
Electric sump pump, pipe	1,438	1,438	1,438	1,707	2,092
Sump	389	389	389	389	389
Total investment	3,548	4,188	5,102	6,809	9,911
Total investment per cow	237	52	34	27	20
Change in annual cost, with 5-year depreciation:					
Depreciation	653	780	957	1,343	1,884
Interest	142	168	204	272	396
Repairs and maintenance	126	126	139	173	216
Insurance	8	8	8	9	9
Electricity	14	72	135	202	389
Labor	33	70	108	158	300
Tractor use	1	2	2	6	12
Total	977	1,226	1,553	2,163	3,206
Cost per cow	65	15	10	9	6
Cost per cwt. milk	.54	.13	.09	.07	.05
Change in annual cost, with useful life depreciation:					
Total	602	765	974	1,323	2,038
Cost per cow	40	10	6	5	4
Cost per cwt. milk 2/	.33	.08	.05	.04	.03

1/ Assumes 50 gallons of wash water per cow per day, 3-week storage capacity for wash water and normal rainfall during the highest rainfall period, plus capacity to store runoff from a 10-year, 24-hour storm event. This is equivalent to 11.1 inches of runoff from the total drainage area of 450 square feet per cow.

2/ Assumes 12,000 pounds of milk per cow per year.

Table 6--Investment, annual cost, and milk production cost for runoff control under various assumptions, Northern, Southeast, and Southwest dairy regions

Item	Northern: Normal rainfall	Northern: 10-year, 24-hour, storm event	Northern: Storm event equivalent to 50% of normal rain-fall	Southeast: Normal rainfall and wash water	Southeast: 10-year, 24-hour, storm event	Southeast: Storm event equivalent to 50% of normal rain-fall	Southwest: Normal rainfall and wash water	Southwest: 10-year, 24-hour, storm event	Southwest: Storm event equivalent to 50% of normal rain-fall
	Dollars								
15-cow herd:									
Investment:									
Total	2,729	2,799	2,927	2,820	2,895	3,132	3,477	3,548	3,655
Per cow	181	187	195	188	193	209	232	237	244
Annual cost per cow	49	50	53	51	52	56	64	65	67
Cost per cwt. of milk 1/	.41	.42	.44	.42	.43	.46	.53	.54	.56
30-cow herd:									
Investment:									
Total	1,928	2,057	2,310	--	--	--	--	--	--
Per cow	64	69	77	--	--	--	--	--	--
Annual cost per cow	18	19	21	--	--	--	--	--	--
Cost per cwt. of milk	.15	.16	.18	--	--	--	--	--	--
80-cow herd:									
Investment:									
Total	2,460	2,747	3,698	3,135	3,528	5,065	3,907	4,188	5,030
Per cow	31	34	46	39	44	63	49	52	63
Annual cost per cow	9	10	13	12	14	18	14	15	18
Cost per cwt. of milk	.07	.08	.11	.10	.11	.15	.12	.13	.15
150-cow herd:									
Investment:									
Total	2,919	3,725	5,258	--	--	--	4,570	5,102	6,452
Per cow	19	25	36	--	--	--	30	34	43
Annual cost per cow	6	7	10	--	--	--	9	10	13
Cost per cwt. of milk	.05	.06	.08	--	--	--	.08	.09	.10
250-cow herd:									
Investment:									
Total	--	--	--	5,799	7,564	12,556	5,630	6,809	9,134
Per cow	--	--	--	23	30	50	23	27	37
Annual cost per cow	--	--	--	8	10	15	7	9	11
Cost per cwt. of milk	--	--	--	.07	.08	.12	.06	.07	.09

See footnote at end of table.

Continued

Table 6--Investment, annual cost, and milk production cost for runoff control under various assumptions, Northern, Southeast, and Southwest dairy regions--continued

Item	Northern			Southeast			Southwest		
	Normal rainfall	10-year, 24-hour, storm event	Storm event equivalent to 50% of normal rain-fall	Normal rainfall and wash water	10-year, 24-hour, storm event	Storm event equivalent to 50% of normal rain-fall	Normal rainfall and wash water	10-year, 24-hour, storm event	Storm event equivalent to 50% of normal rain-fall
	Dollars								
500-cow herd:									
Investment:									
Total	--	--	--	9,681	13,257	21,860	7,585	9,911	14,851
Per cow	--	--	--	19	27	44	15	20	30
Annual cost per cow	--	--	--	7	9	13	5	6	9
Cost per cwt. of milk	--	--	--	.06	.07	.11	.04	.05	.07

1/ Assuming all costs are depreciated over 5 years.
-- = not estimated.

3 weeks' normal rainfall and wash water during the highest rainfall period, plus rainfall from a major storm event.

Because of "fixed" costs for irrigation equipment and diversion terrace excavation, investment costs for the holding pond system do not vary greatly for different size ponds (table 7). Excavation cost is the only substantial variable. 3/

COST OF STORING MANURE

Spreading manure on frozen land is common in the Northern region. It would be a financial burden if these producers have to eliminate this practice and restrict spreading to periods of the year when manure can be incorporated into the soil.

A few dairy operators have relatively expensive liquid manure systems, with built-in storage. A lower cost alternative that now looks feasible is the stacking system, which involves storing manure during the winter months. Total investment for a manure stacking system would range from $4,125 for 15-cow herds to $6,640 for 150-cow herds, or from $275 to $44 per cow (table 8). Most of this additional investment would be for stacking equipment, a tractor-mounted loader on 15-cow farms, and the concrete storage area.

As with runoff control, investment and annual cost per cow for solid manure storage would be substantially lower for large operators than small operators. Increased annual cost per cow, assuming investment is depreciated in 5 years, would range from $81 for the 15-cow herd to $16 for the 150-cow herd. Assuming investment was spread over the expected life of the facilities, annual cost would range from $43 for the 15-cow herd to $10 for the 150-cow herd. These data emphasize the relatively high financial burden for small operators, should pollution guidelines requiring the stacking system be imposed on them.

Cost of producing 100 pounds of milk increases 67 cents (7 percent) on small farms (15 cows) and 13 cents (2 percent) on large farms (150 cows), assuming the stacking-system investment is depreciated over 5 years.

Investment, annual cost, and milk production costs are higher for liquid manure storage than for the stacking system (table 9). Milk production costs increase 84 cents (11 percent) on 30-cow farms and 40 cents (7 percent) on 150-cow farms. Therefore, the lower cost stacking system was used in this study to estimate the aggregate manure-handling costs to the industry, discussed later in this report.

3/ Irrigation costs were based on electric pumps that automatically operate to control the water level in the pond. Sufficient pipe would be needed to apply 3 inches of water per acre per irrigation. Variable labor of 0.8 hour per acre per irrigation would be needed to move the sprinkler gun.

Table 7--Investment, annual cost, and milk production cost, various holding-pond emptying schedules, Northern, Southeast, and Southwest dairy regions

Item	Northern			Southeast			Southwest		
	1 week	2 weeks	3 weeks	1 week	2 weeks	3 weeks	1 week	2 weeks	3 weeks
	Dollars								
15-cow herd:									
Investment:									
Total	2,760	2,788	2,799	2,824	2,859	2,895	3,501	3,526	3,548
Per cow	184	187	187	188	191	193	233	235	237
Annual cost per cow	50	50	50	51	51	52	64	65	65
Cost per cwt. of milk 1/	.41	.42	.42	.43	.43	.43	.54	.54	.54
30-cow herd:									
Investment:									
Total	2,010	2,036	2,057	--	--	--	--	--	--
Per cow	67	68	69	--	--	--	--	--	--
Annual cost per cow	19	19	19	--	--	--	--	--	--
Cost per cwt. of milk	.16	.16	.16	--	--	--	--	--	--
80-cow herd:									
Investment:									
Total	2,633	2,690	2,747	3,154	3,341	3,528	3,947	4,069	4,188
Per cow	33	34	34	39	42	44	49	51	52
Annual cost per cow	9	10	10	12	13	14	15	15	15
Cost per cwt. of milk	.08	.08	.08	.10	.11	.11	.12	.12	.13
150-cow herd:									
Investment:									
Total	3,514	3,620	3,725	--	--	--	4,651	4,876	5,102
Per cow	23	24	25	--	--	--	31	33	34
Annual cost per cow	7	7	7	--	--	--	10	10	10
Cost per cwt. of milk	.06	.06	.06	--	--	--	.08	.08	.09
250-cow herd:									
Investment:									
Total	--	--	--	6,121	6,704	7,564	6,040	6,435	6,809
Per cow	--	--	--	24	27	30	24	26	27
Annual cost per cow	--	--	--	8	9	10	8	8	9
Cost per cwt. of milk	--	--	--	.07	.08	.08	.06	.06	.07

See footnote at end of table

Continued

Table 7--Investment, annual cost, and milk production cost, various holding-pond emptying schedules, Northern, Southeast, and Southwest dairy regions--continued

Item	Northern			Southeast			Southwest		
	1 week	2 weeks	3 weeks	1 week	2 weeks	3 weeks	1 week	2 weeks	3 weeks
	Dollars								
500-cow herd:									
Investment:									
Total	--	--	--	9,802	11,267	13,257	7,850	8,871	9,911
Per cow	--	--	--	20	23	27	16	18	20
Annual cost per cow	--	--	--	7	8	9	5	6	6
Cost per cwt. of milk	--	--	--	.06	.06	.07	.05	.05	.05

1/ Assumes 50 gallons of wash water per cow per day (except in Northern region) and capacity to store runoff from a 10-year, 24-hour storm event.
-- = not estimated.

Table 8--Investment and annual cost for mechanical stacking system for solid manure storage, Northern region dairy farms 1/

Additional facilities and costs	Herd sizes (cows) 15	30	80	150
	Dollars			
Gutter cleaner	--	--	--	--
Mechanical stacker	1,943	1,943	1,941	2,930
Tractor-mounted loader 2/	974	--	--	--
Storage area (no roof)	1,080	1,163	2,171	3,582
Fly spraying equipment	128	128	128	128
Manure spreader (solid)	--	--	--	--
Total investment	4,125	3,234	4,440	6,640
Investment per cow	275	108	55	44
Change in annual cost, with 5-year depreciation:				
Depreciation	824	646	887	1,328
Interest	164	129	177	265
Repairs and maintenance	92	68	89	132
Insurance	10	6	7	10
Taxes	45	46	61	91
Electricity	2	6	14	26
Labor	52	115	380	750
Tractor use	18	11	-71	-187
Total	1,212	1,030	1,548	2,417
Cost per cow	81	34	19	16
Cost per cwt. milk	.67	.29	.16	.13
Change in annual cost, with useful life depreciation:				
Total	641	585	941	1,512
Cost per cow	43	20	12	10
Cost per cwt. milk	.36	.16	.10	.08

1/ Farms were assumed to be using typical manure-handling systems.
2/ It was assumed that most farms with 15-cow herds would not have a tractor-mounted loader, while larger farms would.
-- = not applicable.

Table 9--Investment and annual costs for liquid manure system, Northern region dairy farms

Additional facilities and costs	Herd sizes (cows) 30	80	150
	Dollars		
Gutter cleaner or scraper	1/	1/	1/
Liquid storage tank	8,313	16,084	26,426
Agitating and unloading pump	1,787	2,130	2,130
Manure spreader (liquid)	2,039	2,688	2,688
Manure spreader (solid)	1/	1/	1/
Total investment	12,139	20,902	31,244
Investment per cow	405	261	208
Change in annual cost with 5-year depreciation:			
Depreciation	2,352	4,084	6,116
Interest	566	836	1,243
Repairs and maintenance	176	254	315
Insurance	13	16	16
Electricity	0	0	0
Net change-labor	75	35	-28
Net change-tractor use	-149	-266	-431
Total	3,033	4,959	7,231
Cost per cow	101	62	48
Cost per cwt. milk	.84	.52	.40
Change in annual cost with useful life depreciation:			
Total	1,774	2,301	3,219
Total cost per cow	59	29	21
Total cost per cwt. milk	.49	.24	.18

1/ Farms were assumed to already own these items.

IMPACT OF RUNOFF CONTROL ON NET FARM INCOME

The annual cost of runoff control, which includes operating expenses and repayment of the original investment, represents a direct decrease in net cash income for dairy farm operators. The 1976 estimated net cash income for various size dairy farms in selected locations was compared with the increased annual cost of the pollution control equipment and facilities. This comparison gives a rough indication of the financial burden on dairy farmers in complying with the proposed pollution regulations. 4/

The net cash income data were projected from actual farm account records in the selected States, and probably represent above-average farm operators. The general conclusion is that runoff control would reduce net cash income about 2 percent on farms with 80 or more cows and 5 to 6 percent on farms with 30 or fewer cows (table 10). Net cash income might be reduced 9 to 10 percent on the low-income farms in Wisconsin and other States with 30 or fewer cows, and even more on the less efficient farms in the Northern region. The impact on net farm income in the Southwest region was not estimated because data were not available. North Carolina was the only State in the Southeast region with available data.

AGGREGATE IMPACT OF RUNOFF CONTROL ON U.S. DAIRY INDUSTRY

Total investment for the U.S. dairy industry to control runoff would depend on the cost of additional facilities for various size herds as previously discussed, as well as on the number of producers and the proportion of these producers who must add facilities to keep runoff on their own property.

Number of Dairy Herds

The trend in dairy production has been toward fewer and larger farms. This trend is likely to continue, regardless of pollution control regulations. The number and sizes of dairy farms were projected to 1976, in order to obtain the estimated number of producers in the industry at that time (table 11).

The actual proportion of 1976 producers who will need to invest in runoff control equipment is not known. However, 38 percent of the 2,652 producers surveyed in 1973 by the National Milk Producers Federation said that runoff from an exposed lot entered a continuously flowing stream, either directly or through a natural waterway or dry ditch, at least once each 10 years. Although this survey did not represent all dairy producers, it provides some insight on the extent of the runoff problem, especially among the larger U.S. herds. This study provides a range of investments that would be required by the industry, assuming all or 40 percent of the producers would have to construct runoff control facilities. Some dairy farms already have facilities to retain runoff and wash water. Some of these farms are located in areas where runoff would not enter surface water even after major storm events. Therefore, the upper limit on estimated industry capital investment for runoff control may be overstated.

4/ 1976 net cash income projections assume milk prices equivalent to about 75 percent of parity, and projected increase in input prices. From net cash income (gross income minus cash farm operating expenses and interest payments) the operator must subtract depreciation of farm capital and cost of retiring farm debt. Net income includes the return to operator and unpaid family labor, owned capital, and management.

Table 10--Estimated decrease in projected net cash income for runoff control, selected sizes and locations of dairy farms, 1976

Region and area	Herd size (cows)	Net cash income (estimated, 1976) 1/	Annual cost of runoff control facilities 2/	Share of net cash income
	Number	-------- Dollars	-------	Percent
Northern region:				
New York	Less than 40	15,113	578	3.8
	70-84	26,784	782	2.9
	150 or more	55,163	1,072	1.9
Pennsylvania	20-29	12,336	600	4.9
	70-89	30,711	782	2.5
	110 or more	49,196	1,072	2.2
Michigan (Southern)	Less than 30	9,208	578	6.3
	75-99	38,819	782	2.0
Wisconsin:				
Low income	Less than 30	6,077	578	9.5
High income	Less than 30	16,494	578	3.5
Minnesota (Southern)	25-34	17,413	578	3.3
	55 or more	38,863	782	2.0
Southeast region:				
North Carolina	50-80	33,955	1,083	3.2

1/ In 1976 dollars (not deflated); estimates prepared by George Frick and reported in Impacts of Alternative Dairy Price Support Levels, an unpublished report to Agr. Stab. and Cons. Serv. by Econ. Res. Serv., USDA. Jan. 1973.

2/ Based on current investment costs, with 5-year depreciation.

Table 11--Estimated number of dairy farms, by regions and herd sizes, 48 States, 1976

Region	Herd sizes (cows)					
	1-19	20-49	50-99	100-199	200-299	300+
Northern	50,467	122,847	37,486	5,386	0	0
Southeast 1/	1,767	(-- 2,525 --)		(-- 1,161 --)		453
Southwest 1/	1,751	(-- 739 --)		900	1,085	721
South Central 1/	20,531	(-- 13,863 --)		(-- 2,835 --)		129
Plains and Mountains	16,320	11,638	3,709	1,033	0	0
Northwest	2,426	2,901	2,272	855	0	0
Total	93,262	137,386	60,594	8,174	5,081	1,303
Average herd size for U.S. 2/	6.5	32.7	60	145	246	385

1/ Herd size classes 20-49 and 50-99 and herd size classes 100-199 and 200-299 were combined in Southeast and Southwest regions. This reduced the calculated average herd size for these size classes.
2/ Average herd size and total farms are consistent with the estimated 11,670,000 milk cows in 1976.

Source: U.S. Census Agr., 1969; and projections by David Cummins, Impacts of Alternative Dairy Price Support Levels, unpublished report to the Agr. Stab. and Cons. Serv. by Econ. Serv., USDA, Jan. 1973.

Total Investment for Control

Total industry investment is estimated at $780 million if operators of all dairy farms in the 48 States have to construct and install runoff control facilities (table 12). 5/ This represents an average investment of $2,550 per farm, or $68 per cow. About 65 percent of this cost, or $504 million, would be incurred by operators in the Northern region.

If 40 percent of all dairy farm operators in the 48 States are required to construct runoff control facilities, total additional investment would drop to about $312 million dollars. There would be no change in average investment of $2,550 per farm and $68 per cow.

Aggregate investment would increase about 20 percent (from $780 to $931 million) if facilities were designed to store runoff from a storm event equivalent to 50 percent of annual precipitation, rather than the 10-year, 24-hour storm event (table 12). This change would be equivalent to increasing the runoff storage requirement in the holding pond from 8 to 20 inches in the Northern region, 17 to 39 in the Southeast, and 11 to 21 inches in the Southwest.

Total investment would decrease about 9 percent (from $780 to $711 million) if the water to be stored in the holding pond was reduced from 8 to 3 inches of runoff in the Northern region, 17 to 10 inches in the Southeast region, and 11 to 6 inches in the Southwest.

Exempting Small Producers

About 32 percent of the estimated $780 million required to control runoff would fall on operators of herds with fewer than 20 cows. 6/ If the 93,262 farms of this size were excluded, total industry investment would be reduced $252 million, or to about $528 million (table 13).

About 90 percent of the estimated $780 million investment for runoff control would fall on operators of herds with fewer than 100 cows. If regulations were applied only to the 14,558 dairy herds with 100 or more cows, the total cost would be $80 million, or an average of $5,500 per farm. Exempting the herds with fewer than 100 cows would substantially reduce the impact on the dairy industry, although it would place larger operators at a disadvantage.

Cost of Stacking Manure

The maximum investment for all dairy farm operators in the Northern region and the Plains and Mountain region to adopt a manure stacker system would be $908 million. Assuming 10 percent of the producers currently allow manure to accumulate in the barn, use liquid manure storage, or otherwise store manure

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5/ To obtain this estimate, the same investment cost in the Northern region was extended to producers in the Plains and Mountain region and the Northwest region. Also, the investment in the Southeast was extended to producers in the South Central region. See appendix B for determination of aggregate estimates. 6/ This assumes that all producers with 20 or more cows would install runoff control facilities.

Table 12--Industry investment for runoff storage, specified situations, 48 States

Runoff storage	Northern	Southeast	Southwest	South Central	Plains and Mountains	Northwest	Total	Total: Per farm	Total: Per cow
	Million dollars							Dollars	
All producers:									
Normal rainfall, 3 weeks' wash water, and 10-year, 24-hour storm event	504.3	25.9	27.0	120.3	81.0	21.3	779.8	2,550	68
Normal rainfall and wash water	460.7	22.1	23.4	111.7	74.4	18.7	711.0	2,325	62
Normal rainfall, wash water, and 50 percent of annual storm event	591.5	36.9	33.3	150.3	92.3	26.2	930.6	3,043	81
Normal rainfall, wash water, and 10-year, 24-hour storm event for:									
1 week	493.1	22.3	24.2	112.1	79.5	20.7	752.0	2,459	65
2 weeks	499.4	24.0	25.5	116.4	80.4	21.0	766.7	2,507	67
40 percent of producers:									
Normal rainfall, 3 weeks' wash water, and 10-year, 24-hour storm event	201.7	10.4	10.8	48.1	32.4	8.5	311.9	2,550	68
Normal rainfall and wash water	184.3	8.8	9.4	44.7	29.8	7.5	284.5	2,325	62
Normal rainfall, wash water, and 50 percent of annual storm event	236.6	14.8	13.3	60.1	36.9	10.5	372.2	3,043	81
Normal rainfall, wash water, and 10-year, 24-hour storm event for:									
1 week	197.2	8.9	9.7	44.8	31.8	8.2	300.7	2,459	65
2 weeks	199.8	9.6	10.2	46.6	32.2	8.4	306.8	2,507	67

Table 13--Decrease in total investment by exempting small producers

Item	North	Southeast	Southwest	South Central	Plains and Mountains	Northwest	Total	Per farm
	Million dollars							Dollars
Total investment to control runoff 1/								
All producers	504.3	25.9	27.0	120.3	81.0	21.3	779.8	2,550
Producers with 20 or more cows	369.3	21.1	20.9	64.9	37.3	14.8	528.3	2,481
(Percent decrease)	(27)	(19)	(23)	(46)	(54)	(31)	(32)	
Producers with 100 or more cows	19.7	13.4	18.0	22.2	3.8	3.1	80.1	5,504
(Percent decrease)	(96)	(48)	(33)	(82)	(95)	(85)	(90)	

1/ Assumes capacity for 3-week storage of normal rainfall during the highest rainfall period and wash water plus runoff from a 10-year, 24-hour storm event.

during winter, total investment would be reduced to $817 million. Altogether, a manure stacking system could cost the dairy industry as much as runoff control in all 48 States. Of the total amount, about 30 percent would be spent on herds with fewer than 20 cows; 86 percent would be spent in the Northern region alone.

Average investment for Northern region farms that must both control runoff and avoid spreading manure during winter months could exceed $6,000 per farm.

APPENDIX A

Alternative Systems for Runoff Control

This section provides more detailed description and design assumptions of the runoff control alternatives considered in this study. Similar information for the manure stacking system is also given. 7/

Settling basin--holding pond system

An area of 50 square feet per cow of paved lot and 250 square feet per cow of unpaved lot was assumed for all herd sizes in the Northern and Southeast regions. In the Southwest region, 50 square feet per cow of paved lot and 325 square feet per cow of unpaved lot were specified. The total area draining into the holding pond, including the surface area of the pond itself, was 450 square feet per cow. Rainfall on buildings was guttered outside the polluted water diversion.

In all cases, the holding pond was 10 feet deep. At this depth, the bottom of the pond would be below ground water level in many areas, such as the Southeast. However, it was assumed that internal pressure as the pond filled, plus the sealing action of wastes not trapped in the settling basin, would prevent inward seepage of groundwater so that it would not be necessary to line the pond.

A settling basin to prevent most of the solids from entering the holding pond was included in the system for the Northern and Southeast regions. In the Southeast, sand would be carried by the cows to the washing area, and be flushed away during washing operations. The settling basin collects these solids that would otherwise fill the holding pond.

The settling basin, assumed to be situated perpendicular to the flow of lot runoff, was designed to store 1 inch of sediment from the unpaved portion of the lot, 8/ and 1.5 inches runoff from the entire lot. 9/ The basin was 5 feet deep with a concrete bottom. Concrete was charged at $30 per cubic yard, labor at $19 per cubic yard, and excavation at $0.50 per cubic yard. The concrete basin floor was sloped to allow for gravity flow of liquid wastes into the holding pond and for ease in removing solids. Variable operating costs included labor and machine expense required to remove accumulated solids by a manure loader and conventional manure spreader.

7/ The authors thank James Moore, Dept. of Agr. Eng., Univ. of Minn., for helpful suggestions and guidance in designing the systems. However, all responsibility for system design is assumed by the authors.

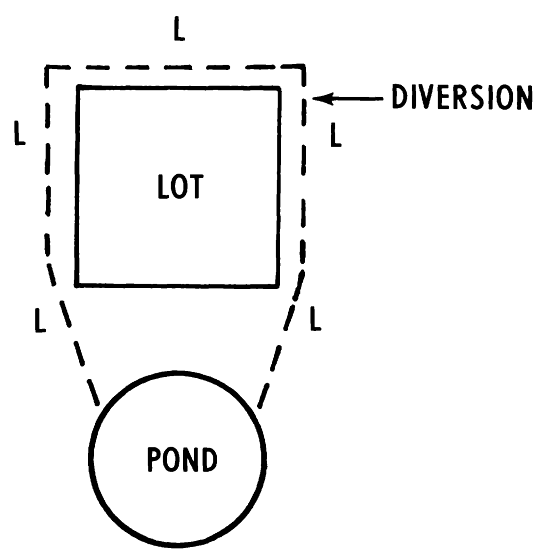
8/ Source: Minn. Soil Cons. Serv. Standards and Specifications, Sect. IV-425, March 1972.

9/ Source: Mich. Soil Cons. Serv. Engineering Standard, Technical Guide, Sect. IV-G, March 1970.

Settling basins were not included in the holding pond systems for the Southwest region. Runoff from lots plus wash water would flow to a concrete sump, 6 feet cube size, at the edge or corner of the lot. Concrete was charged at $98 per cubic yard. A 3-inch electric, self-priming, centrifugal pump with an automatic float switch would pump the waste water through a 3-inch aluminum pipe to the holding pond. A pipeline length of 400 feet with a vertical lift of 40 feet was assumed for all herd sizes.

Clean water would be diverted away from the lot and housing structures by means of a diversion dike or terrace. It was assumed that the diversion dike or terrace would be located as close to the lot and buildings as possible to minimize the flow of runoff from the nonlot area into the holding pond. Diversion dikes were based on the lot dimensions. A square lot, with one side equal to L, was assumed. The diversion terrace length was 5L; 3L was the diversion around the lot and 2L was the diversion below the lot to the pond, as illustrated below.

Diversion dikes were assumed to have a top width of 4 feet, a height of 5 feet, and a bottom width of 9 feet. 10/ Excavation costs were charged at $0.50 per cubic yard for the holding pond, diversions, and settling basin.



For the Southwest region, where the general layout of dairy farms prohibits construction of the holding pond below the lot, a diversion length of 3L was used.

10/ Source: Minn. Soil Cons. Serv. Standards and Specifications, "Diversions," Sect. IV-A-362.

Holding ponds and lagoons were enclosed with four-strand barbed wire and pine post fencing, which meets ASCS recommendations for Minnesota. 11/ Fencing was placed 10 feet from the perimeter of the pond. Posts were placed 16 feet apart.

The irrigation system included a 3-inch aluminum pipeline, 25 and 40 hp. low head centrifugal pumps, and a "big gun" liquid manure sprinkler. A fixed length of 200 feet of pipe was assumed for all situations. As storage requirements increased, additional pipe was added. The pipeline was assumed to pivot at any coupling, thus allowing coverage of about three times the area covered by a stationary line and sprinkler. An application rate of 3 inches of waste water per acre, with disposal on pasture or meadow, was assumed for all herd sizes. (14)

Pump sizes were selected to allow for waste water disposal within 72 hours for all herd sizes except the 250-cow and 500-cow herds in the Southeast region. There, using a 40 hp. pump, disposal time for 3 weeks' wash water and runoff storage plus 50 percent of annual precipitation was slightly over 83 hours in the 250-cow herd and 166 hours for the 500-cow herd.

Anaerobic Lagoon System

The Michigan Soil Conservation Service defines an anaerobic lagoon as "an impoundment made by constructing an excavated pit, dam embankment, dike, or levee or combination of these for biological treatment of organic waste." A lagoon differs from a holding pond in that wastes are retained in the lagoon to allow decomposition of organic materials.

Lagoons were designed for use in the Southern region, where climate and topography are favorable, but they are also used in the Northern States. They approach maximum efficiency in warm climates, such as Florida's. Because of restricted space, infrequent rainfall, and a high rate of evaporation, lagoons are impractical in most of the Southwest region.

The lagoon system includes a diversion terrace above the lot for diversion of runoff from the exposed lot and housing area; a flushing system; the lagoon; a settling basin for sand removal; an overflow basin; a pump for disposal of lagoon overflow into surface irrigation canals; and fencing to keep animals and children away from the lagoon.

For this study, the lagoon provided 1,200 cubic feet per cow. Excavation costs were computed at $0.50 per cubic yard.

Flushing the barn floor with a 4- to 6-inch wall of water would transport the waste through a ditch to the lagoon. It was assumed that wastes would be conducted by gravity flow, thus precluding the need for a sump and discharge pump. Waste and rinse waters from the milkhouse can also be flushed into the

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11/ Barbed wire was 12½ guage, 2 barb, at $14.83 per 80-rod spool. Posts were 3½ inches by 7 feet, at $1.12 per post. Labor was charged at half the cost of the materials.

drainage ditch. The lagoon would also serve as a receptacle for storm waste runoff. The lagoon was designed to stabilize at a given water level; thus, an excess runoff must be pumped out to maintain the proper balance between liquids and solids.

Because wash water and lot runoff exceed the capacity of the lagoon designed for the Southeast region, an overflow basin with a 1-week storage capacity was provided. Also provided were a 25-hp. centrifugal pump, a 3-inch aluminum pipe, and a "big gun" sprinkler to empty the overflow basin. It is realized that cleaning operations would be necessary at some future time, but no costs for this work were included.

Liquid manure storage

Liquid storage tanks were assumed to be located adjacent to the barn or housing structure. They were designed for a 6-month storage capacity, based on a storage requirement of 2.6 cubic feet per cow per day. (8)

The storage tank was designed with poured, reinforced-concrete walls, and floor 6 inches thick; a precast cover; and openings for unloading and agitating the waste. Tanks for the 30-cow dairy farms were 10 feet deep; tanks for larger farms were 15 feet deep. Allowance was made for unusable space at both the top and bottom of the tank. Construction costs were estimated at $98 per cubic yard of concrete for walls and cover, and $84 per cubic yard for the floor. Costs included forms, concrete, steel reinforcement, and labor. 12/ Excavation cost was set at $0.50 per cubic yard.

The liquid slurry would be moved by a PTO (power take off) driven pump into a liquid manure spreader, and then spread on the land. Spreaders with 1,100-gallon capacity were designed for 30-cow herds, and with 1,500-gallon capacity for the larger herds.

A liquid storage system was not designed for the 15-cow herd because of its impracticality for that size operation and the high investment cost.

Manure stacking system

A dairy manure production of 1.5 cubic feet per cow was assumed for the manure stacking system. (2) The storage structure was designed with 6-foot poured concrete walls, 6 inches thick, and curved to accommodate the swinging of the stacker. Concrete costs were estimated at $24 per cubic yard for walls and floor. 13/ Labor was charged at half the cost of materials. All labor was assumed to be hired, with wages at the upper end of the scale. If the dairy operator provides the labor, construction costs would be lower.

The manure stacker was designed with a wheeled undercarriage and lift. A 2-hp., single-phase motor with a 40-foot elevator was designated for farms with 30 cows and under; a 2-hp., single-phase motor with a 50-foot elevator for

12/ Based on Minn. Soil Cons. Serv. Area Engineers Survey conducted by the authors, March 1973.

13/ Based on Minn. Soil Cons. Serv. Area Engineers Survey conducted by the authors, March 1973.

farms with 31 to 149 cows; and a 3-hp., single-phase motor with a 60-foot elevator for farms with 150 or more cows. It was assumed that most herds of 30 or more cows in the Northern region had a mechanical gutter cleaner to which a stacker unit could be attached. Wastes would then be transported by the stacker unit and deposited in the storage structure. For dairy herds with fewer than 30 cows a litter carrier or wheelbarrow would convey wastes from the barn to the stacking area. A small, two-wheeled sprayer was also designed into the system for fly control as wastes accumulate in the stack. Stored wastes would be disposed by a tractor-mounted loader and a conventional manure spreader.

Appendix table A-1 shows investment costs for selected runoff control equipment.

Computing Annual Cost of Runoff Control

A straight-line depreciation schedule was used for the various system components; salvage value was 10 percent for all machinery, and zero for manure storage structures, runoff collection, and retention facilities.

Useful life was assumed to be 15 years for all items and structures except the sump and irrigation pumps, which have a useful life of 10 years. (8)

Interest was charged at 8 percent on half of the original investment.

Repair costs were calculated for all items of machinery, based on a percentage of original cost (app. table A-2).

Insurance costs were calculated on the basis of \$0.77 per \$100 market value. Market value was computed at half the difference between the actual investment cost (x), and the ratio (y) of salvage value to actual investment [$mv = \frac{1}{2}(x - yx)$]

Taxes were based on a third of the market value, times 115 mills per dollar.

Electricity cost was determined at a rate of 1 kw. per hp. per hour of use (12), charged at a rate of \$0.03 per kw. hour. 14/ Electricity use was based on the amount of water handled by the sump and irrigation pumps in the sump pit, holding pond, and overflow basin.

Changes in labor and tractor costs were determined by comparing the requirements for the existing "typical" situations with requirements for the alternative systems. Labor and costs for irrigation were based on a rate of .8 hour per irrigation (17). An additional 10 hours per year for setup and breakdown time were included for all herd sizes. Labor and tractor time for cleaning the settling basin were calculated on the basis of the cubic feet of sediment removed, using a conventional 220-cubic-foot manure spreader and assuming a 15-minute loading time for a front-mounted loader and 45 minutes travel and spreading time.

14/ Northern States Power Company Consumer information representative, Minneapolis, Minn.

Labor was charged at a rate of $2.50 an hour. Tractor use was charged at a rate of $0.87 an hour; this rate included $0.73 an hour for fuel and oil 15/ and $0.14 an hour 16/ for repairs.

Average milk production per cow per year for all herd sizes was assumed to be 12,000 pounds.

Table A-1--Investment for selected runoff control equipment

Item	Original cost
	Dollars
Mechanical stacker: 1/	
40-foot elevator and 2-hp. electric motor	1,943
50-foot elevator and 2-hp. electric motor	2,141
60-foot elevator and 3-hp. electric motor	2,930
Liquid manure spreader: 2/	
1,100 gallon	2,039
1,500 gallon	2,688
Sprayer 3/	128
Tractor-mounted loader 4/	974
Sprinkler irrigation pump:	
25-hp. electric centrifugal pump	877
40-hp. electric centrifugal pump	1,137
Self-priming centrifugal sump pump: 5/	
7.5-hp. 3-inch (150 gpm)	1,118
10-hp. 3-inch (200 gpm)	1,387
15-hp. 4-inch (300 gpm)	1,772
Liquid manure pump:	
10-foot length, PTO driven	1,787
15-foot length, PTO driven	2,130
Irrigation pipe (per foot)	.80
"Big gun" irrigation sprinkler	300

1/ Includes a wheeled undercarriage and lift. 2/ Includes tires, freight, and assembly costs. 3/ Includes pump, regulator valves, hoses, and hand gun. Does not include small trailer or barrel. 4/ Includes shipping and assembly charges. Loader has 2,300 pound capacity, with a 4-foot bucket. 5/ Electric motors with automatic flotation switches.

15/ Sources: Fuel use rate from Agricultural Planning Data for the Northeastern United States, Agr. Econ. and Rural Soc., Agr. Exp. Sta., AE and RS 51, Penn. State Univ., July 1965. Fuel cost from Farmers Union Oil Assn., St. Paul, Minn. 16/ Agr. Eng. Yearbook, Amer. Soc. of Agr. Eng., St. Joseph, Mi., 1965.

Table A-2--Repair rates as a percent of investment, runoff control equipment

Item	Repair rate
	Percent
Mechanical stacker	2.3
Tractor-mounted loader	2.6
Solid manure spreader	3.2
Liquid manure spreader	2.4
Insect sprayer	3.0
Irrigation: liquid manure and sump pumps	4.3
Irrigation pipe	4.3
Sprinkler	4.3
Fencing	2.5
Tractor	1/ 1.2

1/ Rate per 100 hours, or $0.14 per hour of operation.

APPENDIX B

Total investment for all producers in the three major regions to control runoff was estimated as follows:

$$\sum_{i=1}^{6} \sum_{j=1}^{6} I_{ij} \; N_{ij} \; P_{ij}$$

Where:

I_{ij} = the total investment required by the operator of the ith size farm in the jth region.

N_{ij} = the number of dairy farms of the ith size in the jth region.

P_{ij} = proportion of dairy farms of ith size in the jth region that have a runoff problem.

A different set of investments (I_{ij}) was used when the basic design assumptions changed. For example, a set of I_{ij} was developed for the 10-year, 24-hour storm event and another set for the storm event equivalent to 50 percent of annual rainfall. These estimated investment requirements represented total investment for operators with herd sizes corresponding to the average herd size of each group of producers as follows: farms with 1-19 cows, 6.5 average; farms with 20-49 cows, 32.7 average; farms with 50-99, 60 average; farms with 100-199 cows, 145 average; farms with 200-299 cows, 246 average; and farms with 300 or more cows, 385 average (table 11).

To obtain a range on total investment, based on different proportions of producers in each size group who would have to construct facilities, P_{ij} was assumed constant at 1 and 0.4.

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